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Pacing in age group marathoners in the 'New York City Marathon'

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Abstract

The aim of the study was to investigate how women and men age group runners pace during a large city marathon. We analysed changes in running speed by splits of 5 km in 20,283 women and 28,282 men age group runners competing in the 2015 edition of the 'New York City Marathon'. A moderate split×sex interaction on running speed ($p<0.001$, $\eta^2=0.108$) was observed with men showing a larger decrease in speed from the fastest split (5-10 km) to the slowest one (35-40 km) than women (21.1 versus 16.7%), and a different pattern was observed in the 25-30 km split (increase in women, decrease in men). A trivial split×age group interaction on speed was observed in women ($p<0.001$, $\eta^2=0.003$) and men ($p<0.001$, $\eta^2=0.004$). In summary, men and women of all age groups reduced running speed during the marathon with a final spurt in the last segment (*i.e.* 40 to 42.2 km).

Key words: athlete, master, performance, elderly people

Introduction

Marathon is one of most challenging endurance Olympic events. In addition to elite athletes participating in this event aiming to run 42.195 km as fast as possible, there is an increasing number of recreational runners of all ages during the last decades whose primary target is to cope with the high physiological load of the race and be a finisher in a marathon (Ahmadyar et al. 2016, Jokl et al. 2004, Lepers and Cattagni 2012). Among other parameters such as training, nutritional and psychological preparation, adopting an optimal pacing strategy is a key factor for a successful finish in a marathon (Angus 2014, Santos-Lozano et al. 2014). Pacing strategy during athletic performance can be defined as the process where total energy expenditure during exercise is regulated on a moment-to-moment basis in order to ensure that the exercise bout can be completed as fast as possible (Baron et al. 2011). There seemed to be differences between unexperienced and experienced athletes. Experienced athletes develop a stable template of the power outputs they are able to sustain for different durations of exercise. However, it is not known how they originally developed this template or how that template changed with training and experience (Baron et al. 2011). Abbiss and Laursen (2008) describe six different pacing strategies during athletic performance such as (*i*) negative pacing (*i.e.* increase in speed over time), (*ii*) positive pacing (*i.e.* continuous slowing over time), (*iii*) all-out pacing (*i.e.* maximal speed possible), (*iv*) even pacing (*i.e.* same speed over time), (*v*) parabolic-shaped pacing (*i.e.* positive and negative pacing in different segments of the race) and (*vi*) variable pacing (*i.e.* pacing with multiple fluctuations).

In long-distance running, different studies investigated pacing strategies of mainly elite runners in 10 km (Lima-Silva et al. 2010), half-marathon (Hanley 2015), marathon (Buonristiani and Martin, 1993, Renfree and St Clair Gibson 2013, Santos-Lozano et al.

2014) and ultra-marathon (Hoffman 2014, Lambert et al. 2004) running. However, little is known for age group runners for different running distances and different performance levels (Hanley 2014, Renfree et al. 2015, Rüst et al. 2015). For age group runners, pacing has been investigated in senior men competing in the World Cross Country Championships (Hanley 2014), in elite 100-km ultra-marathoners competing in the World Masters Championships (Renfree et al. 2015) and in recreational 100-km age group ultra-marathoners (Knechtle et al. 2015, Rüst et al. 2015), but not in marathoners.

Indeed, we have little knowledge of pacing in age group marathoners. For age group marathoners, it is known that they increased their participation and improved their performance in the last decades (Ahmadyar et al. 2016, Jokl et al. 2004, Lepers and Cattagni 2012). March et al. (2011) investigated a small sample of 186 men and 133 women marathoners from the 2005, 2006, and 2007 races of a Midwestern U.S. marathon and found that older, women, and faster are better pacers than younger, men, and slower marathoners, respectively.

Detailed information about the pacing pattern in women and men age group runners would have practical implications for both sport scientists and coaches working with marathon runners in order to develop sex- and age-tailored race strategies and training programs. The aim of the present study therefore was to investigate how women and men age group runners pace during a large city marathon. We analyzed the changes in running speed in age group marathoners (20,283 women and 28,282 men runners) competing in the 2015 edition of the 'New York City Marathon'.

Methods

Ethics approval

The study was approved by the Institutional Review Board of St. Gallen, Switzerland, with waiver of the requirement for informed consent given that the study involved the analysis of publicly available data.

Data sampling and data analysis

All data were obtained from the official and publicly accessible website of the 'New York City Marathon' (www.tcsnycmarathon.org). We limited data analysis to the year 2015 in order to eliminate a potential influence of different weather conditions in different race editions since environmental conditions have a considerable influence on marathon race times (Ely et al. 2008, Trubee et al. 2014). The temperature ranged from 14ºC to 18ºC (www.timeanddate.com/weather/usa/new-york/historic). We included all women and men runners of all 5-year age groups from < 20 years to 80-84 years in order to avoid a selection bias by analyzing only a limited sample of top runners such as the top 10 or top 100 of each age group. Initially, data on 20,673 women and 28,780 men runners were obtained from the marathon's website and considered for inclusion. Exclusion criteria were that (*i*) at least one split time was missing and (*ii*) running time differed between two consecutive splits for more than 100%. After this initial screening, 390 (1.9%) women and 498 (1.7%) men runners were excluded from further analysis. Therefore, 20,283 women and 28,282 men runners were included in the present study.

The 'New York City Marathon' presents certain relatively small changes in its elevation (www.tcsnycmarathon.org/sites/default/files/NYC%20Marathon%20Elevation%20Profile_20

14.pdf). It starts at an elevation of 29.3 m, decreases by -8.0 m in the 0-5 km split and by -9.1 m in the 5-10 km split, increases by +1.8 m in the 10-15 km split, decreases by -3.6 m in the 15-20 km split, increases by +30.7 m in the 20-25 km split, decreases by -39.0 m in the 25-30 km split, and then increases continuously in the 30-35 km (+6.1 m), 35-40 km (+13.7 m) and 40-42 km split (+3.7 m) to end at an elevation of 25.6 m.

Statistical analysis

Statistical analyses were performed using IBM SPSS v.20.0 (SPSS, Chicago, USA) and GraphPad Prism v. 7.0 (GraphPad Software, San Diego, USA). Data were expressed as mean and standard deviations of the mean (SD). A factorial repeated measures analysis of variance (ANOVA) examined the effects of split and sex on speed, where the within-subjects factor was split and the between-subjects factor consisted of sex. In addition, a factorial repeated measures ANOVA studied the effects of split and age group on speed separately for each sex, where the within-subjects factor was split and the between-subjects factor was age group. Subsequent comparisons among splits were carried out using post-hoc Bonferroni test. The magnitude of the differences among splits was examined using effect size eta squared (η^2) and was evaluated as following: small ($0.010<\eta^2\leq0.059$), moderate ($0.059<\eta^2\leq0.138$) and large ($\eta^2>0.138$) (Cohen, 1988). The men-to-women ratio was calculated by dividing the overall number of men through the overall number of women for each age group. The change in the men-to-women ratio across age groups was investigated using single linear regression analysis. Significance level was set at alpha=0.05.

In addition, we used a multivariate regression analysis to model changes in speed across race by sex and age group accommodating the effect of gradient according to Angus and Waterhouse (2011). In the model, we constructed the following variables: (*a*) speed of split

(SP); (*b*) number of split (NUM), from 1 to 9, *e.g.* 1 corresponded to 0-5km split and 2 to 5-10km split; (*c*) a dummy which obtains 1 if it is the first segment, 0 otherwise (START); (*d*) a dummy which obtains 1 if it is the last segment, 0 otherwise (END); and (*e*) the change (in meters) between the end of the split and the start of the split (GRAD) .

Results

Most of the finishers were ranked in age group 40-44 years (Table 1). However, regarding the sexes, most women were in age group 30-34 years and most men in age group 40-44. The men-to-women ratio increased across age groups (r^2=0.60, p=0.0012).

Table 2 and Table 3 present the split times for women and men, respectively. A factorial repeated measures ANOVA in the overall sample showed a moderate split×sex interaction ($p<0.001$, η^2=0.108), *i.e.* the pacing patterns differed by sex, in which men showed a larger decrease in running speed from the fastest split (5-10 km) to the slowest one (35-40 km) than women (21.1 versus 16.7%) and a different pattern was observed in the 25-30 km split (*i.e.* increase in women, decrease in men) (Figure 1). There was a large main effect of split ($p<0.001$, η^2=786), in which all splits differed among them with regards to running speed. Speed increased from 0-5 km to 5-10 km split (+0.11 km·h^{-1}), thereafter it decreased during 10-15 km (–0.23 km·h^{-1}), 15-20 km (–0.28 km·h^{-1}) and 20-25 km splits (–0.65 km·h^{-1}). It increased in 25-30 km split (+0.03 km·h^{-1}) and again it decreased during 30-35 km (–0.59 km·h^{-1}) and 35-40 km splits (–0.25 km·h^{-1}), whereas a final increase was observed in the last 2.195 km (+0.48 km·h^{-1}) (Figure 2).

In women, a factorial repeated measures ANOVA revealed a trivial split×age group interaction ($p<0.001$, η^2=0.003). Moreover, there was a moderate main effect of split on running speed ($p<0.001$, η^2=0.076). Running speed increased from 0-5 km to 5-10 km split (+0.08 km·h^{-1}), then it decreased during 10-15 km (–0.24 km·h^{-1}), 15-20 km (–0.28 km·h^{-1}) and 20-25 km splits (–0.60 km·h^{-1}). It increased in 25-30 km (+0.10 km·h^{-1}) and again it decreased during 30-35 km (–0.47 km·h^{-1}) and 35-40 km split (–0.14 km·h^{-1}). There was an increase in the last split (+0.50 km·h^{-1}) (Figure 3).

In men, a trivial split×age group interaction ($p<0.001$, $\eta^2=0.004$) and a moderate main effect of split ($p<0.001$, $\eta^2=0.116$) were observed. Running speed increased from 0-5 km to 5-10 km split (+0.15 km·h^{-1}). Thereafter, it decreased during all splits (10-15km, –0.23 km·h^{-1}; 15-20 km, –0.28 km·h^{-1}; 20-25 km, –0.70 km·h^{-1}; 25-30 km, –0.05 km·h^{-1}; 30-35 km, –0.70; 35-40 km, –0.35 km·h^{-1}) except the last one (+0.45 km·h^{-1}) (Figure 4).

The findings of the multivariate regression analysis are presented in Table 4. The constant coefficient ranged from 7.701 (age group 75-79 years) to 10.593 (age group 25-29 years) in women and from 8.325 (age group 75-70 years) to 12.339 (age group 20-24 years) in men. The coefficient of split number (NUM) was from -0.313 (age group <20 years) to -0.152 (age group 75-79 years) in women and from -0.437 (age group 20-24 years) to -0.258 (age group 75-79 years) in men.

Discussion

This study investigated the change in running speed across time stations in women and men age group runners competing in the 2015 edition of the 'New York City Marathon'. The most important findings were (*i*) men and women of all age groups reduced running speed during the marathon with a final spurt in the last segment (*i.e.* 40 to 42.2 km) and (*ii*) running speed decreased more in men compared to women with a difference in the 25-30 km split.

Decrease in running speed with a final spurt

A main finding of the present study was that a general pattern of pacing was observed for all runners independently of sex and age group, where running speed gradually decreased from the fastest split (*i.e.* 5-10 km) till the slowest split (*i.e.* 35-40 km), and there was an increase in the last split. The decrease of the running speed across splits was shown by the multivariate analysis, where the coefficient NUM was negative. The final spurt was also observed in the multivariate regression analysis (*i.e.* the coefficient END was positive) for both sexes and all age groups. A final spurt as also been reported for 100-km ultra-marathoners competing in the '100km Lauf Biel' (Knechtle et al. 2015). The authors assumed that the negative pacing in the last segment (TS3-Finish) was most likely due to environmental conditions, such as early dawn during the race and the flat circuit in segment TS3-Finish of the race. In the 'New York City Marathon' however, the race is held during daylight and the course is relatively more flat. A final end spurt has also been reported for master freestyle swimmers (Nikolaidis and Knechtle 2017). The occurrence of a final spurt might be due to psychological factors. Pacing is a combination of anticipation, knowledge of the end-point, prior experience and sensory feedback (Skorski and Abbiss 2017). The knowledge of the near finish might motivate the runners to mobilize the last reserves.

However, our findings differ from the findings in the study of Santos-Lonzano et al. (2014). These authors analysed 190,228 finishers of the 'New York City Marathon' competing between 2006 and 2011 and separated the finishers into four performance groups depending upon their final net time. They found that top runners paced more even during the race and slowed down on average whereas the rest of the runners exhibited a final burst. The most likely explanation for the difference between our findings and their findings is the fact that they separated their runners into four performance groups based upon their race time whereas we analysed the runners recorded in their age group.

Differences pacing strategies seem to exist between slower and faster runners also in half-marathon running. In women and men competing in the IAAF World Half Marathon Championships, the best men and women largely maintained their split speeds between 5 km and 15 km, whereas slower athletes had decreased speeds from 5 km onwards (Hanley 2015).

Differences between women and men in pacing

Another major finding was the different patterns of pacing between women and men, in which running speed decreased from the fastest to the slowest split more in men than in women, and difference was revealed in the 25-30 km split (*i.e.* running speed increased in women and decreased in men).

Indeed, differences in pacing between women and men long-distance runners seem to exist. In marathon running, men are more likely to slow down than women (Deaner et al. 2015). Santos-Lozano et al. (2014) found a significant difference between women and men in the final total time, in the speed-split and in the pace in all splits. Significant differences were also observed between all performance levels within each sex. In 100-km ultra-marathoners, women showed lower relative starting speeds and higher finishing speeds than men (Renfree et al. 2015).

An unexpected finding in our analysis was that a different pattern was observed in the 25-30 km split where running speed increased in women but decreased in men. The split 25-30 km is just after the half of the marathon (*i.e.*21.1 km). A potential explanation could be motivational factors that the runners have achieved the half of the race. However, also physiological differences between women and men marathoners might explain this difference (Helgerud et al. 1990, Helgerud 1994). When female and male marathon runners with similar performance were matched, the performance of women was poorer, *i.e.* their oxygen uptake during running at a standard submaximal speed was higher. Also when heart rate, respiratory exchange ratio and concentration of blood lactate were compared, it was obvious that a given running speed resulted in higher physiological strain for women compared to men (Helgerud et al. 1990). Maximum oxygen uptake (VO_2max) is about 10% higher in men compared to women and women have a lower VO_2 than men when running at comparable velocities (Helgerud 1994). When elite female and male runners competing at World class level were compared in running economy, men used less oxygen at common absolute velocities, but VO_2max was not different between women and men at equal relative intensities (%VO_2max). When women and men of equal VO_2max were compared, men were significantly more economical than women (Daniels and Daniels 1992). Another explanation could be that the race course and/or the wind conditions could have had an effect on the split 25-30 km. This is possible because most men reached this 5 km window ahead of most women and the environmental conditions could have changed.

No differences between age groups

In this study, we investigated whether a difference in pacing for the different age groups occurred. However, we found for both women and men a split×age group interaction of trivial magnitude. Similarly, in 100-km ultra-marathoners competing in the World Masters Championships, pacing remained consistent across age categories (Renfree et al. 2015). In 100-km ultra-marathoners competing in the '100km Lauf Biel' athletes in age group 18-24 years were slower than athletes in most other age groups and older athletes were not slowing down faster than younger athletes (Rüst et al. 2015).

Most probably, age has no major influence on pacing in marathon running although March et al. (2011) found that that older runners, women, and faster runners are better pacers than younger runners, men, and slower runners. In the present study, the athletes in the older age groups had the slowest running times. However, the pacing pattern was similar for age groups within each sex. An explanation for this similarity might be that the perception of fatigue likely did not differ among age groups. In a comparison between 7 and 13.1 miles running events, Faulkner et al. (2008) observed that the perception of fatigue had distinct temporal characteristics during distance running, *i.e.* the runners adjusted their perception according to the proportion of exercise time that remained. Thus, despite running slower, the older age groups adjusted their speed in a similar pattern as the younger groups did. Most probably differences do exist in pacing for age group athletes between sports disciplines. In master freestyle swimmers competing in the FINA World Masters Championships 2014 in 100, 200, 400, and 800 m freestyle in age groups 25-29 years to 90-94 years, a moderate to large lap×age group interaction was reported from 100 to 800 m, *i.e.,* pacing patterns differed by age groups (Nikolaidis and Knechtle 2017).

Limitations, strength and practical applications

The 'New York City Marathon' might be considered as a city flat marathon with the elevation being ~80 m and, consequently, the findings of this study should be generalized to marathons with similar elevation characteristics. Also, the pacing patterns identified in this marathon were based on data from 5 km splits. Although this pattern was in agreement with previous findings using same distance of splits, using splits of higher frequency (*e.g.* 1 km) might show highly variable patterns (Angus and Waterhouse, 2011). That was, caution was needed when providing more detailed instructions for pacing in shorter splits using data from 5 km splits. Another limitation was that since the New York City marathon did not set an official time limit, we analysed all finishers. Including finishers with an average speed equivalent to walking might have a confounding effect on pacing. Instead, we excluded the finishers who showed extreme changes in speed from split to split. In addition, we did not analyse those who did not finish (DNF) and the DNF rates by sex and age group. The 'New York City Marathon' is is a point-to-point race with the finish line miles from the start. The effects of wind and topography do not balance as they would in a race with the start proximal to the finish. However, the energy cost of overcoming air resistance is only ~2% for marathon running (Davies 1980) and can be neglected. Nevertheless, strength of the present study was that, unlike recent research (Zavorsky et al., 2017), it analysed all finishers, instead of selected (*e.g.* winners or 100 fastest), avoiding the selection bias. A marathon running race is a major Olympic event with increasing popularity and participation of runners of all ages over the last decades. Therefore, the identification of sex- and age-specific general patterns of pacing would be great help for runners and personnel involving in their training (*e.g.* coaches). These patterns of pacing might serve as a guide for those planning to participate in marathon with similar characteristics as the 'New York City Marathon'. Based to these patterns of pacing, a runner can develop their own pacing according to sex and age in order to optimize performance. Further studies should examine the combined effect of performance level and age group on pacing, *i.e.* whether runners with similar race time but different age pace differently or whether the fastest runners (*e.g.* the fastest quartile) of each age group differ for pacing.

Conclusions

In summary, in age group runners competing in the 2015 edition of the 'New York City Marathon', men and women of all age groups reduced running speed during the marathon with a final spurt in the last segment (*i.e.* 40 to 42.2 km). The running speed decreased more in men compared to women with a different trend in the 25-30 km split (*i.e.* speed increased in women and decreased in men), and a split×age group interaction of trivial magnitude was observed in women and in men.

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Table 1 Finishers in the present study and men/women ratio by age group

Age group	Total	Women	Men	Men-to-women ratio
<20	140	75	65	0.87
20-24	1,506	872	634	0.73
25-29	5,693	3,238	2,455	0.76
30-34	7,474	3,580	3,894	1.09
35-39	7,659	3,217	4,442	1.38
40-44	8,463	3,360	5,103	1.52
45-49	7,015	2,607	4,408	1.69
50-54	5,503	1,889	3,614	1.91
55-59	2,933	881	2,052	2.33
60-64	1,414	397	1,017	2.56
65-69	520	113	407	3.60
70-74	180	42	138	3.29
75-79	54	8	46	5.75
80-84	11	4	7	1.75
Total	48,565	20,283	28,282	1.39

Table 2 Split times (min:s) and finish times (h:min:s) in female finishers by age groups

Age group	5 km	10 km	15 km	20 km	25 km	30 km	35 km	40 km	42 km	Finish
<20	32:03±4:09	32:13±4:42	33:33±5:25	35:41±7:02	38:40±9:10	37:59±8:00	40:50±9:36	40:56±8:34	16:25±3:21	5:08:19±54:03
20-24	30:58±4:33	30:44±4:53	31:41±5:17	32:57±6:09	35:26±7:10	35:17±7:22	37:12±7:33	37:35±7:30	15:21±2:58	4:47:11±49:13
25-29	30:48±4:23	30:32±4:43	31:21±5:01	32:28±5:45	34:50±6:44	34:39±6:54	36:46±7:35	37:09±7:12	15:14±2:59	4:43:48±47:22
30-34	31:14±4:36	31:08±5:05	31:50±5:11	32:59±6:00	35:29±7:10	35:13±7:18	37:15±7:49	37:45±7:37	15:28±3:04	4:48:21±50:09
35-39	31:31±4:41	31:22±5:09	32:10±5:21	33:15±6:05	35:48±7:07	35:22±7:09	37:26±7:46	37:55±7:19	15:38±3:00	4:50:27±50:07
40-44	31:43±4:42	31:36±5:13	32:20±5:21	33:28±6:09	35:58±7:08	35:29±7:04	37:38±7:44	38:09±7:33	15:46±3:03	4:52:06±50:26
45-49	31:50±4:39	31:47±5:16	32:36±5:26	33:45±6:11	36:21±7:08	35:54±7:09	38:03±7:50	38:33±7:29	15:58±3:04	4:54:47±50:31
50-54	32:14±4:51	32:07±5:20	33:00±5:30	34:08±6:09	36:50±7:08	36:18±7:06	38:36±7:42	39:13±7:21	16:17±3:02	4:58:43±50:34
55-59	32:59±4:53	33:08±5:39	34:12±5:55	35:32±6:37	38:12±7:18	37:43±7:16	39:58±7:39	40:35±7:29	16:54±3:08	5:09:12±52:42
60-64	34:28±5:09	34:47±5:46	35:49±5:58	37:06±6:37	40:04±7:13	39:20±7:25	41:31±7:12	41:59±7:02	17:36±3:05	5:22:40±52:07
65-69	36:59±5:57	37:29±6:34	38:32±6:25	39:57±6:43	42:54±7:11	42:27±7:17	44:21±6:52	44:57±6:46	18:48±3:11	5:46:22±52:49
70-74	38:05±4:56	38:46±4:57	40:15±5:38	42:38±7:41	44:21±6:46	43:47±6:50	46:03±7:17	46:29±4:55	19:42±3:07	6:00:04±49:10
75-79	40:17±3:34	39:38±3:21	41:54±3:16	42:48±3:50	45:41±2:41	43:12±4:57	46:04±5:11	46:46±6:10	20:22±3:15	6:06:42±30:27
80-84	38:39±6:03	38:13±4:59	38:51±4:55	40:17±4:42	43:18±3:54	42:06±3:44	45:00±3:21	45:16±3:44	19:15±1:42	5:50:54±35:54
Total	31:38±4:44	31:32±5:14	32:20±5:26	33:29±6:11	36:02±7:11	35:39±7:13	37:46±7:48	38:16±7:31	15:47±3:05	4:52:29±50:46

Data are presented as mean±standard deviation.

Table 3 Split times (min:s) and finish times (h:min:s) in male finishers by age groups

Age group	5 km	10 km	15 km	20 km	25 km	30 km	35 km	40 km	42km	Finish
<20	29:10±5:15	28:31±5:08	29:19±5:21	30:32±6:07	33:11±7:25	34:15±8:52	37:17±9:03	37:21±7:54	14:58±3:02	4:34:33±52:49
20-24	27:39±4:41	27:13±4:50	27:47±4:59	29:02±6:00	31:32±7:07	32:08±7:42	34:49±8:30	35:45±8:32	14:37±3:32	4:20:29±49:45
25-29	27:41±4:45	27:14±4:48	27:45±4:56	28:46±5:54	31:09±7:19	31:37±7:42	34:17±8:35	35:29±8:24	14:32±3:15	4:18:31±50:52
30-34	27:48±4:43	27:24±4:48	27:59±5:03	28:56±5:55	31:20±7:16	31:53±7:56	34:26±8:36	35:44±8:18	14:45±3:18	4:20:16±51:42
35-39	27:59±4:34	27:33±4:35	28:08±4:51	29:03±5:36	31:26±6:58	31:46±7:21	34:28±8:06	35:49±8:00	14:49±3:10	4:21:01±49:10
40-44	28:09±4:36	27:49±4:44	28:24±4:55	29:16±5:34	31:37±6:52	31:56±7:20	34:34±8:03	35:52±7:50	14:57±3:12	4:22:34±49:04
45-49	28:34±4:29	28:15±4:41	28:57±5:03	29:51±5:44	32:17±7:04	32:26±7:24	35:04±8:04	36:19±7:49	15:10±3:13	4:26:54±49:35
50-54	29:06±4:35	28:49±4:55	29:31±5:05	30:25±5:41	32:51±6:54	33:02±7:11	35:49±8:00	37:05±7:50	15:30±3:18	4:32:08±49:25
55-59	30:03±4:40	29:50±5:04	30:38±5:15	31:43±6:02	34:26±7:16	34:36±7:25	37:26±8:08	38:31±7:51	16:05±3:13	4:43:18±50:49
60-64	30:44±4:53	30:41±5:24	31:33±5:42	32:38±6:18	35:20±7:22	35:32±7:48	38:22±8:33	39:23±8:12	16:28±3:27	4:50:42±53:37
65-69	33:00±5:18	33:13±5:56	34:17±6:19	35:34±7:01	38:54±8:21	38:46±8:07	41:30±8:39	42:21±8:33	17:41±3:44	5:15:15±57:31
70-74	35:38±6:29	36:08±7:22	37:01±7:27	38:50±8:08	42:14±8:57	41:52±9:12	44:22±8:43	45:15±8:30	18:53±3:39	5:40:12±1:03:13
75-79	38:38±6:27	39:09±6:35	40:42±7:04	42:38±7:34	45:47±7:24	44:58±7:01	47:20±7:08	48:52±7:57	20:48±3:28	6:08:53±56:10
80-84	38:28±5:56	39:14±6:59	41:39±9:01	42:45±9:29	46:53±9:25	46:16±7:30	50:15±11:57	52:55±14:46	24:37±10:23	6:23:01±1:16:06
Total	28:34±4:47	28:14±5:00	28:53±5:15	29:50±5:59	32:18±7:17	32:36±7:39	35:17±8:22	36:31±8:09	15:10±3:20	4:27:23±51:41

Data are presented as mean±standard deviation.

Table 4 Coefficients of regression analysis of running speed

Age group	A	B	C	D	E	SEE	R^2
	Coefficients of regression analysis						
Women							
<20	10.016	-0.313	-0.223	1.138	-0.005	1.55	0.157
20-24	10.524	-0.292	-0.368	0.994	-0.004	1.61	0.121
25-29	10.593	-0.286	-0.399	0.928	-0.004	1.60	0.118
30-34	10.416	-0.275	-0.359	0.896	-0.004	1.64	0.107
35-39	10.322	-0.271	-0.361	0.848	-0.005	1.60	0.110
40-44	10.249	-0.266	-0.353	0.805	-0.005	1.59	0.108
45-49	10.194	-0.272	-0.336	0.806	-0.005	1.56	0.118
50-54	10.101	-0.279	-0.354	0.773	-0.005	1.49	0.134
55-59	9.791	-0.276	-0.260	0.763	-0.005	1.49	0.137
60-64	9.292	-0.252	-0.187	0.704	-0.005	1.37	0.141
65-69	8.639	-0.236	-0.125	0.707	-0.004	1.25	0.148
70-74	8.156	-0.205	0.018	0.552	-0.004	1.06	0.173
75-79	7.701	-0.152	-0.113	0.301	-0.008	0.71	0.239
80-84	8.357	-0.221	-0.279	0.535	-0.005	0.72	0.343
Men							
<20	11.813	-0.432	-0.771	1.231	-0.004	2.09	0.145
20-24	12.339	-0.437	-0.759	1.108	-0.004	2.09	0.151
25-29	12.317	-0.414	-0.771	0.916	-0.004	2.13	0.136
30-34	12.235	-0.412	-0.750	0.850	-0.004	2.10	0.141
35-39	12.118	-0.403	-0.745	0.809	-0.005	1.96	0.154
40-44	11.984	-0.391	-0.692	0.744	-0.005	1.92	0.154
45-49	11.739	-0.377	-0.647	0.718	-0.005	1.85	0.157
50-54	11.535	-0.377	-0.642	0.719	-0.005	1.77	0.168
55-59	11.135	-0.375	-0.578	0.768	-0.005	1.72	0.175
60-64	10.810	-0.356	-0.493	0.738	-0.005	1.69	0.167
65-69	9.961	-0.330	-0.350	0.793	-0.004	1.60	0.163
70-74	9.220	-0.303	-0.275	0.748	-0.004	1.53	0.155
75-79	8.325	-0.258	-0.104	0.531	-0.004	1.36	0.162
80-84	8.480	-0.321	-0.223	0.282	-0.004	1.34	0.263

A, B, C, D and E are coefficients of the regression
SP=A+B*NUM+C*START+D*END+E*GRAD+ERROR
SP=running speed; NUM=split (from 1 to 9); START= a dummy which obtains 1 if it is the first split, 0 otherwise; END=a dummy which obtains 1 if it is the last split, 0 otherwise; GRAD=change in gradient (in meters) between the end and the start of the split; SEE=standard error of the estimate; R^2=coefficient of determination.

Figure captions

Figure 1 Running speed by splits in female and male finishers. Error bars represent standard deviations.

Figure 2 Changes (%) in running speed from split to split in female and male finishers. Error bars represent standard errors.

Figure 3 Running speed by splits in female finishers

Figure 4 Running speed by splits in male finishers

Figure 1

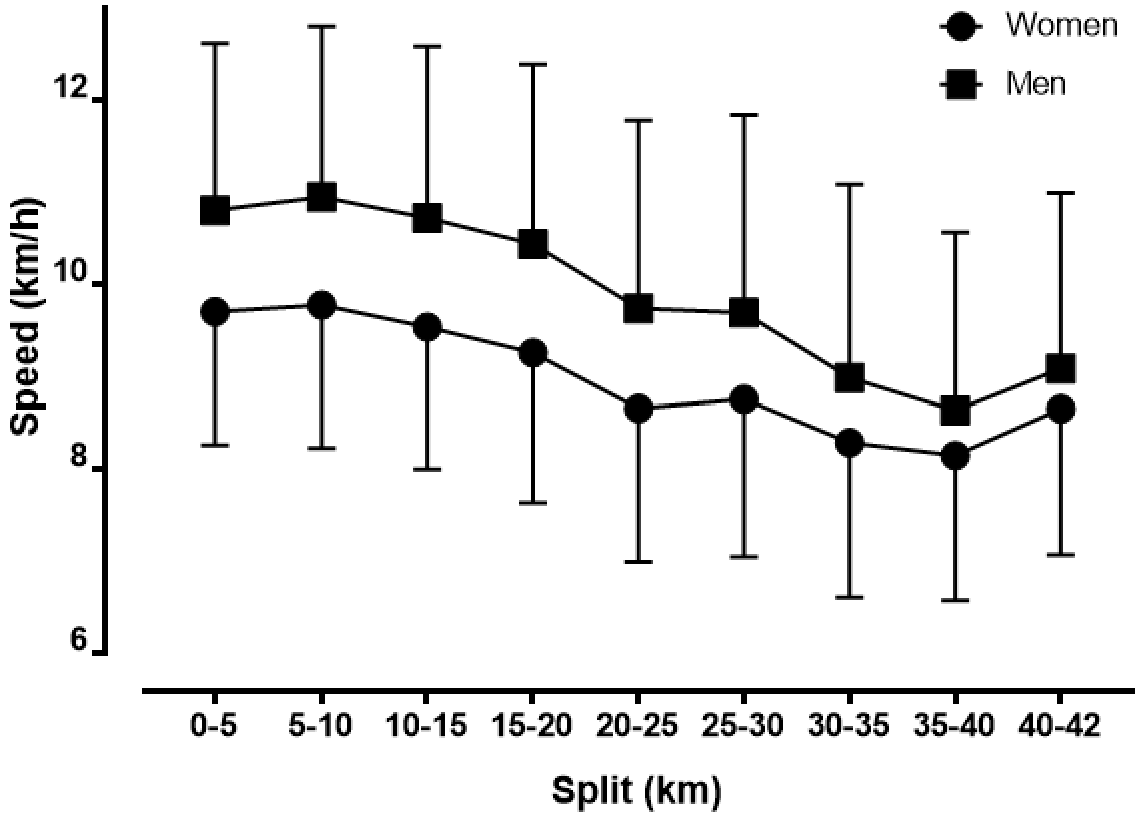

Women
Men
12
10
8
6
Speed (km/h)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-42
Split (km)

Figure 2

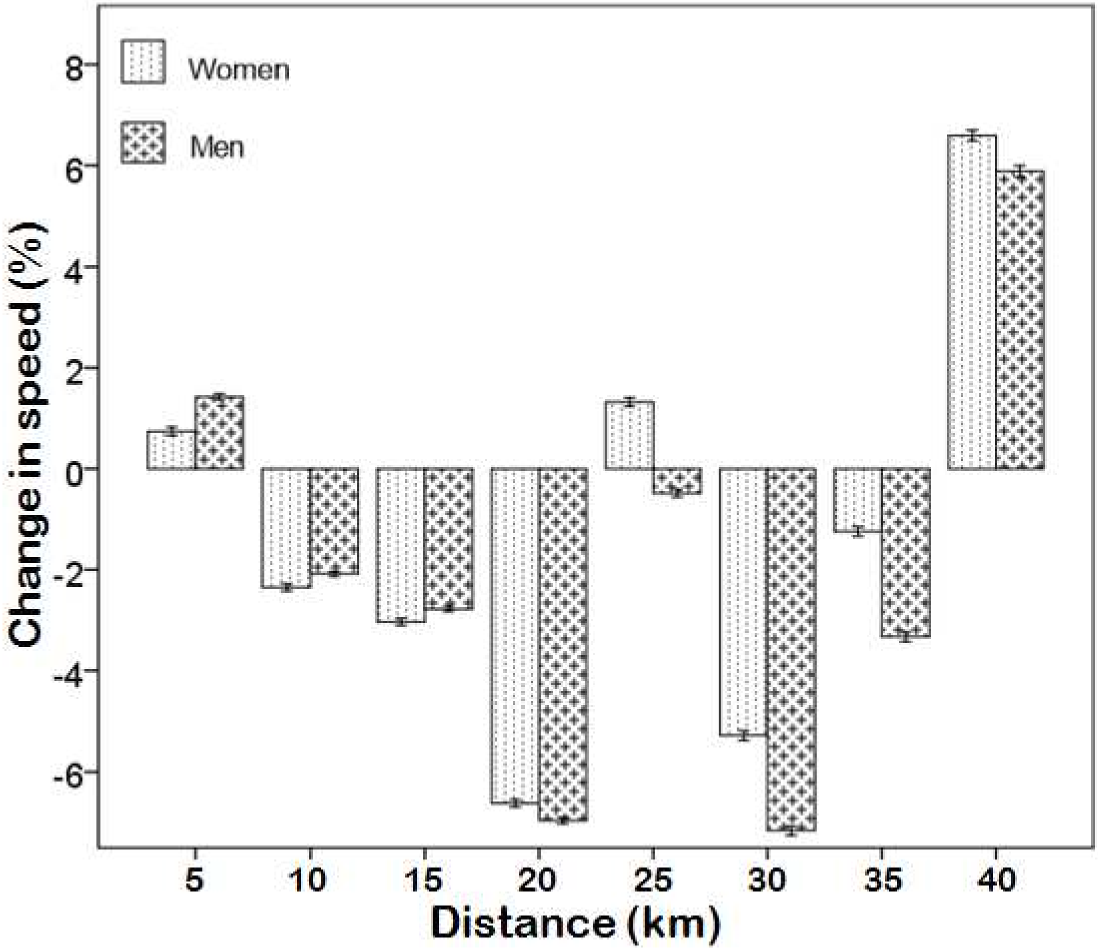
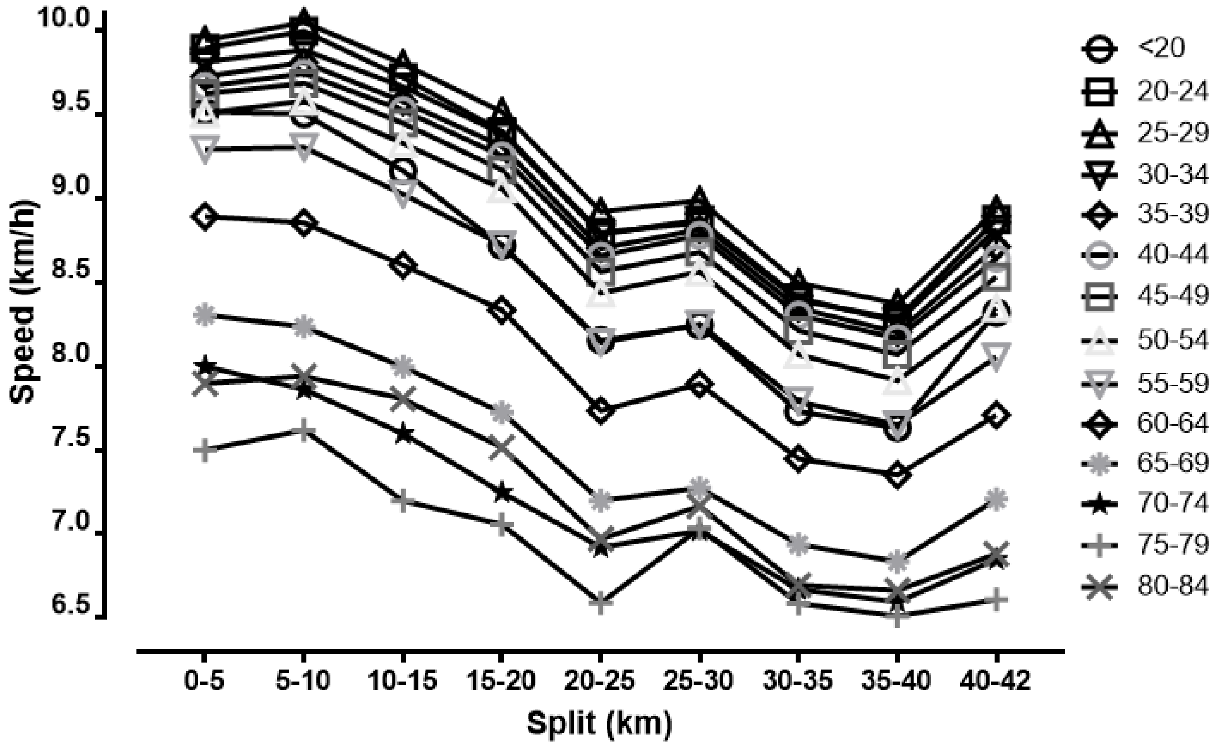
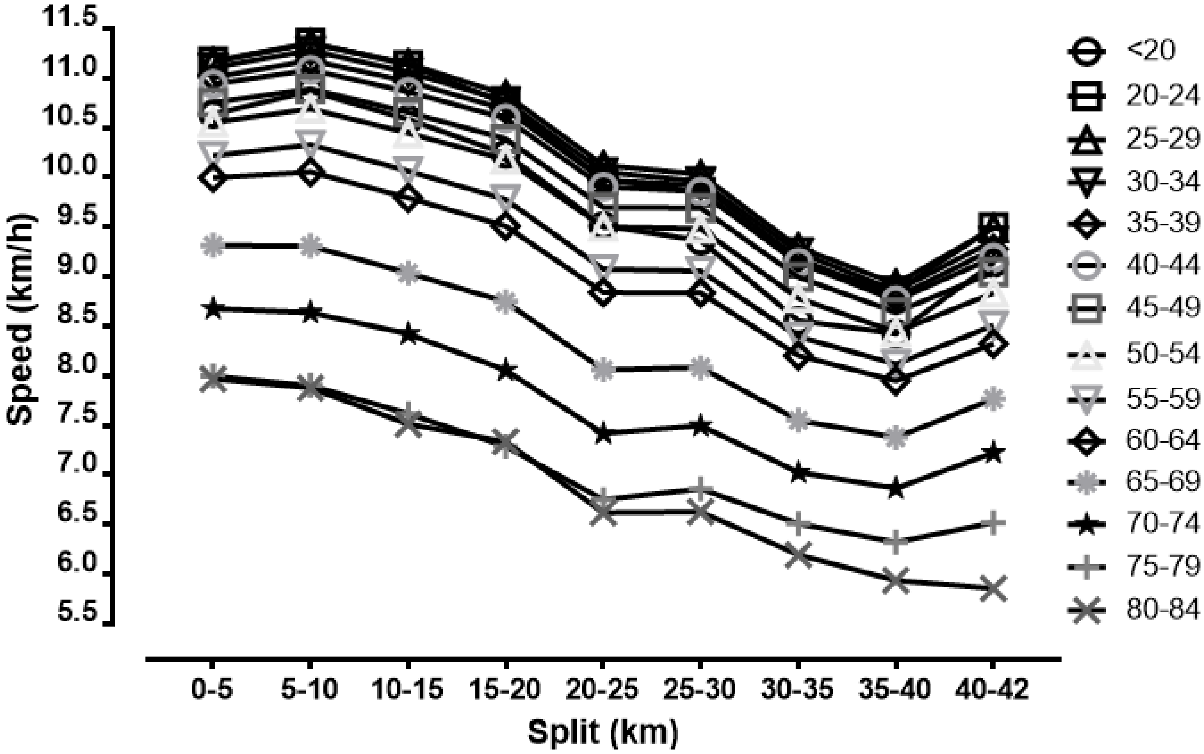

Women
Men
Change in speed (%)
8
6
4
2
0
-2
-4
-6
5
10
15
20
25
30
35
40
Distance (km)

Figure 3



10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
Speed (km/h)
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-42
Split (km)
<20
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84

Figure 4



Speed (km/h)
11.5
11.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
0-5
5-10
10-15
15-20
20-25
25-30
30-35
35-40
40-42
Split (km)
<20
20-24
25-29
30-34
35-39
40-44
45-49
50-54
55-59
60-64
65-69
70-74
75-79
80-84